

4. Experiments on Colour-changes of the Spotted Salamander (*Salamandra maculosa*), conducted in the Society's Gardens. By E. G. BOULENGER, F.Z.S. (Curator of Reptiles).

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(Plates I. & II. : Text-figure 1.)

The remarkable experiments conducted in recent years at the Biologische Versuchs-anstalt, Vienna, by Kammerer on the action of modified environment on certain Batrachians have attracted much attention, and a good deal of criticism. Prof. E. W. MacBride, F.R.S., to whom I am indebted for much help and advice, suggested to me last year that an attempt to repeat the experiments conducted by Kammerer with the Spotted Salamander (*Salamandra maculosa*), on the correlation between the coloration and the conditions under which Salamanders may be subjected to, would be of special interest. According to Kammerer, an increase of the bright colour takes place on a yellow soil, especially when the animals are kept in terraria coloured yellow in such a manner that yellow rays of light fall on the Salamanders, whilst the reverse takes place when they are kept in the dark on black humus. Further, he claimed to have succeeded in the extremely difficult task of inducing his Salamanders, which he kept under the above conditions, to breed in captivity, and states that the offspring inherited the characters of their parents, being yellower or blacker than the normal, according to the surroundings in which the first generation had been placed. During the past year I have been keeping under conditions similar to those referred to by Kammerer a large number of Salamanders received from the French Jura, thanks to the kindness of Mme. Phisalix of the Pasteur Institute, but it is as yet too early to expect any striking changes, and the present paper deals with the results obtained by repeating certain experiments conducted by Kammerer's pupil, Secerov, who kept Salamander larvæ in aquaria under yellow or black conditions*. Secerov unfortunately started his experiments with only four larvæ, the offspring of a Salamander of the variety *teniata*. Two of these larvæ were placed in an aquarium coloured yellow and two in an aquarium coloured black. The results he obtained were as follows:—

That Salamanders kept in yellow surroundings when in the larval stage were on transformation yellower than their mother: that the spots were larger and had a tendency to fuse together.

That the reverse takes place when Salamander larvæ are kept in black surroundings, the transformed animal being darker than the mother: that the spots are smaller and more numerous.

* 'Biologisches Centralblatt,' 1914.

In January of this year (1920), I was given a pregnant Salamander of the variety *teniata*, which I was informed was received from Western Germany. In this specimen (see text-fig. 1), in which neither the black nor the yellow can be said to predominate, the dorsal spots are confluent into broad bands along each side.

On February 2nd this Salamander gave birth to 32 young, and half the larvæ were immediately placed in aquaria 16 inches square, entirely painted orange-yellow, whilst the other half were placed in similar aquaria painted black all over. In the

Text-figure 1.



course of their larval life 12 of these young Salamanders died, 7 of those placed in the yellow aquaria, and 5 of those in the black aquaria. Of these, however, two in each set died only just prior to transformation, having developed the yellow and black pigments of the perfect animal. It will be observed from the figures on Plates I. & II. that in these experiments the results obtained by Secerov were fully confirmed, the majority of the Salamanders which had been kept in yellow surroundings when in their larval condition being on transformation yellower than the mother, and the spots larger and fused together: the Salamanders

kept in black surroundings being on transformation darker than the mother, and the spots smaller and more numerous.

To appreciate fully the markings on these Salamanders it is, however, necessary to bear in mind the fact that it is possible to define two forms of *S. maculosa*. As I pointed out in a paper brought before this Society some years ago*, authors in dividing this Salamander into a number of varieties have dwelt on supposed structural characters, whilst ignoring the disposition of the markings. I showed that two principal forms existed, namely, the typical form and the variety *teniata*: the former, in which the yellow appears as markings of various shapes disposed anyhow over the body, being more or less an eastern form; the latter, in which the dorsal spots are regularly disposed in two parallel series continuous with the markings on the parotoids, being a more western form. The markings in the last referred to variety may form regular bands or be broken up into numerous small spots, which, however, always retain their duplex disposition, not encroaching over the black vertebral area, or, if they do so, as is rarely the case, they will be connected by a cross-bar in an H-shaped form. The habitat of the *forma typica* appears to be bounded to the west by the Erz Mountains, the Danube, the Alps, and the Rhone, Salamanders from east and south of that line belonging to it. All over France, west and north of the Rhone, Belgium, S. Holland, Western Germany, Spain, and Portugal the variety *teniata* alone occurs, with very rare exceptions. Both are found together only on the line of demarcation, such as in the French Jura, where the variety *teniata* predominates, but is not completely fixed.

Even amongst Salamanders from the neighbourhood of the line of demarcation it is rare to experience any difficulty in classifying them into either of the two forms, and I was therefore much puzzled by Secerov's results, as neither of his Salamanders kept during their larval life under yellow surroundings were quite normal *teniata*. One of these Salamanders was specially abnormal, as two spots on the anterior part of the body fused together over the vertebral area; and I should have felt some doubt in referring it to the variety *teniata*, had I not known the mother to be a very typical specimen of this form.

The results I have obtained help to solve the problem, as they show that in the majority of cases, if the offspring of a Salamander of the western variety *teniata* is kept when in the larval conditions in yellow surroundings, the markings will differ in their disposition from those of the parent, and be similar in their arrangement to what we find in the typical eastern form, in which the spots are disposed in an irregular fashion over the vertebral area.

* "A Contribution to the Study of the Variation of the Spotted Salamander," P.Z.S. 1911.

Plate II. shows the nine Salamanders kept during aquatic life in yellow surroundings on or just prior to their transformation, and it will be observed that six are referable to the typical form, two are somewhat doubtful, and one only could possibly be regarded as belonging to the variety *teniata*. Plate I. shows those kept in black aquaria, and it will be noticed that the spots are disposed in parallel series, as would be expected from the offspring of Salamanders of the striped variety.

On transformation the young of specimens of the variety *teniata* from the French Jura, which is, as referred to above, on the line of demarcation where both forms occur, are often referable to the typical form; the spots, however, in the course of time change their disposition, breaking up, and disappearing on the vertebral area, so that within a year the Salamanders are similar to their parents in the arrangement of their markings. I have no doubt that we shall find this to be the case with the Salamanders which in their larval form have been brought up in yellow surroundings, and that the spots will in time assume the same duplex disposition as presented by their parents, and brethren brought up when in the larval form in black surroundings.